GSFC SOMO Technology Development Program

Space Internet Work Area Overview

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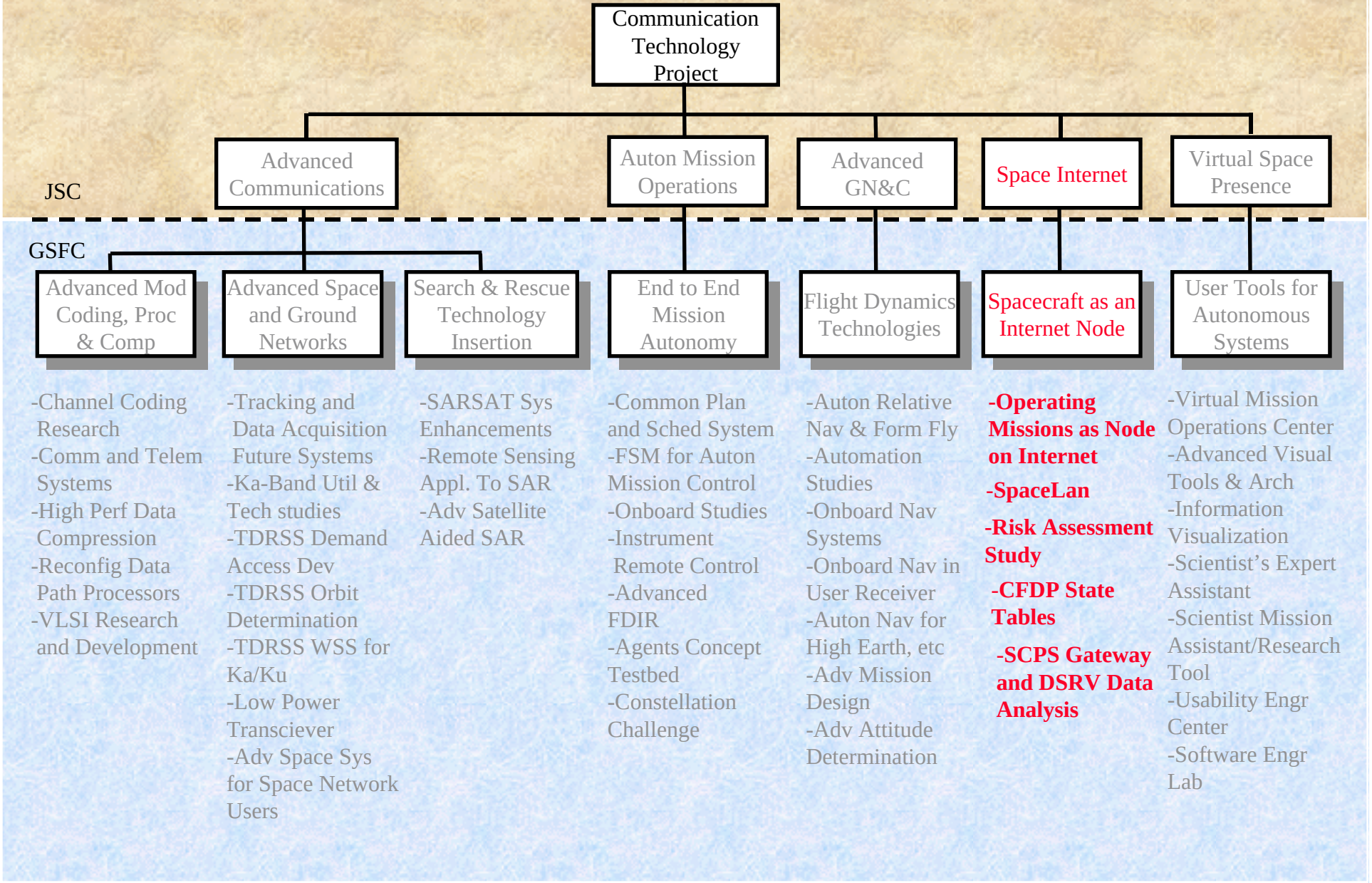
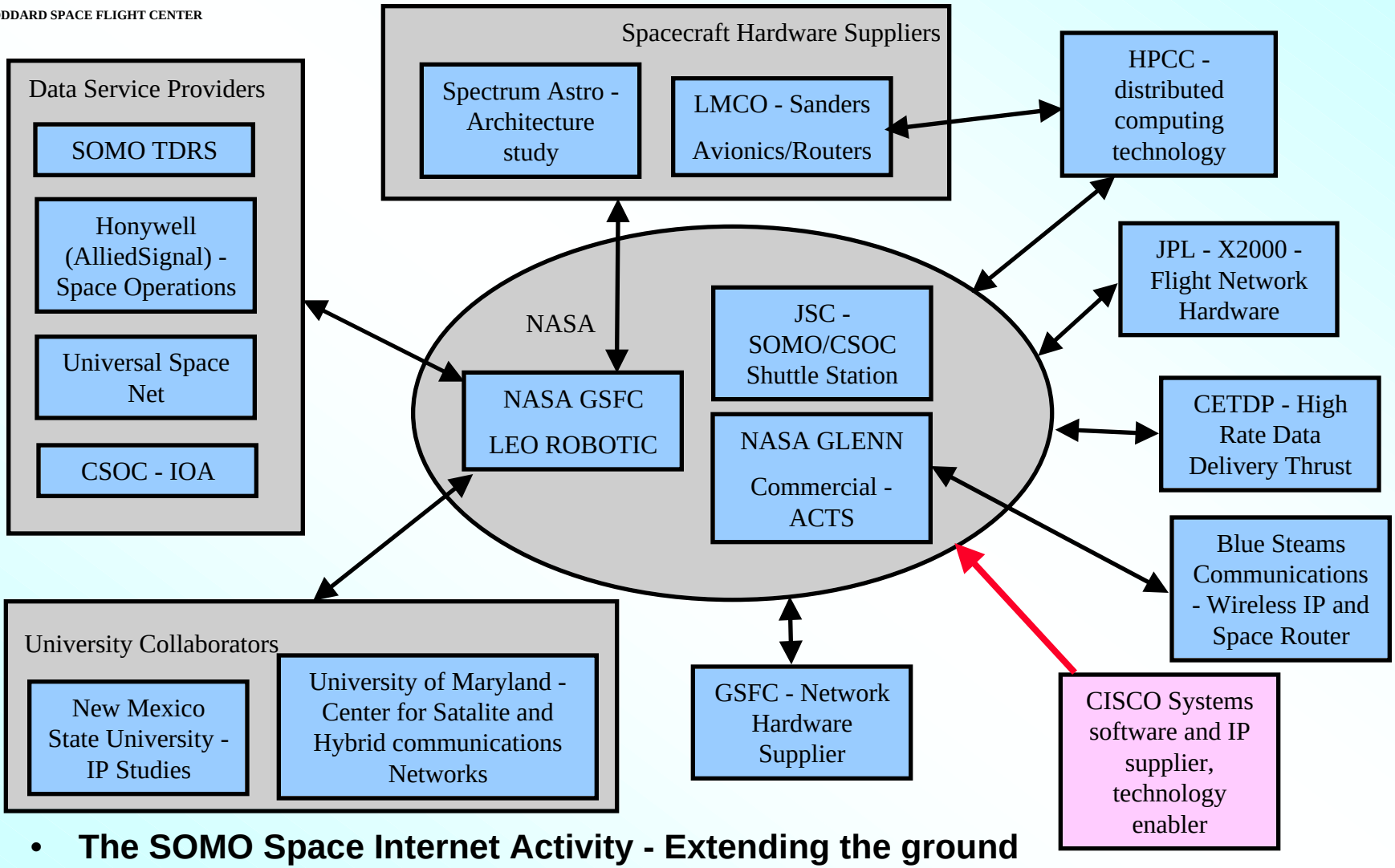
GSFC SOMO Technology Program Structure



Space Internet Campaign Linkages

GODDARD SPACE FLIGHT CENTER



- **The SOMO Space Internet Activity - Extending the ground based Internet to space based assets**
- **Advocating and enabling the use of Internet Protocol Networks on Spacecraft**

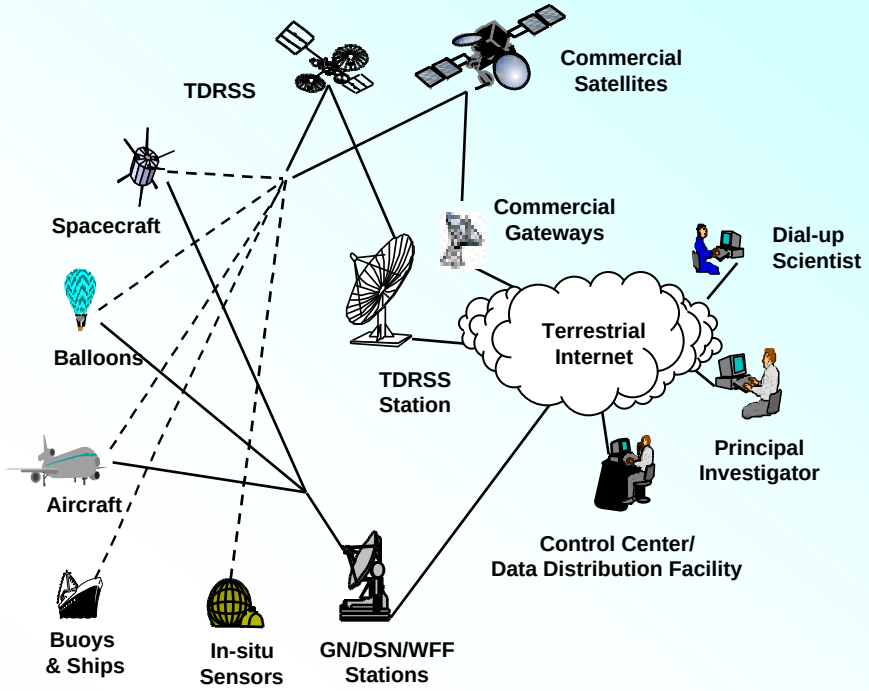
5810_Spacecraft as an Internet Node (SIN) Work Area Roadmap

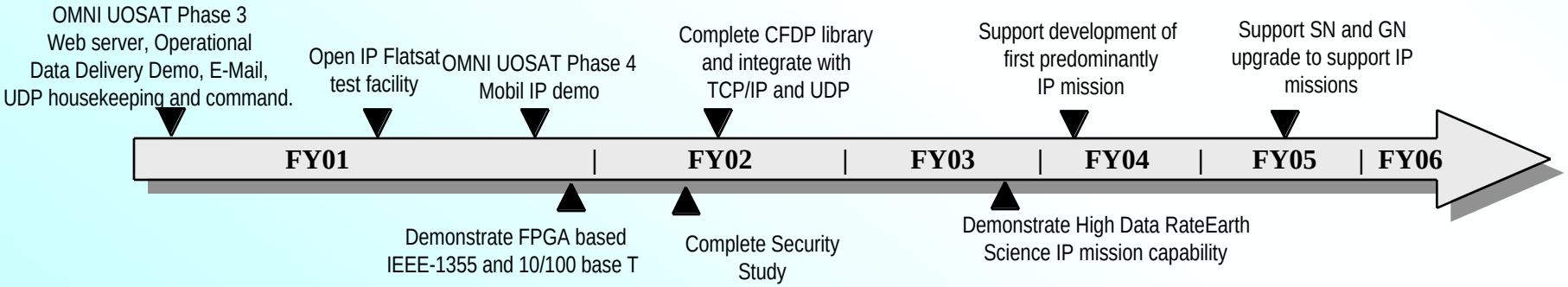
Objective

- Investigate, develop, test, and demonstrate Internet technologies that enable Space Operations vision for transparent operations for earth and space science missions.

Products

- **Full IP mission Lab - Flatsat.**
- **Flight Demonstration of IP operations concepts using UOSAT-12, including TCP/IP, UDP, Web servers, E-Mail.**
- **Development of flight qualified network hardware supporting TCP/IP protocol stacks.**
- **CFDP Reliable file transfer library interfaced to TCP/IP and UDP**
- **Security studies and demonstrations**
- **Engineering support for infusion of IP technologies into the first IP mission.**



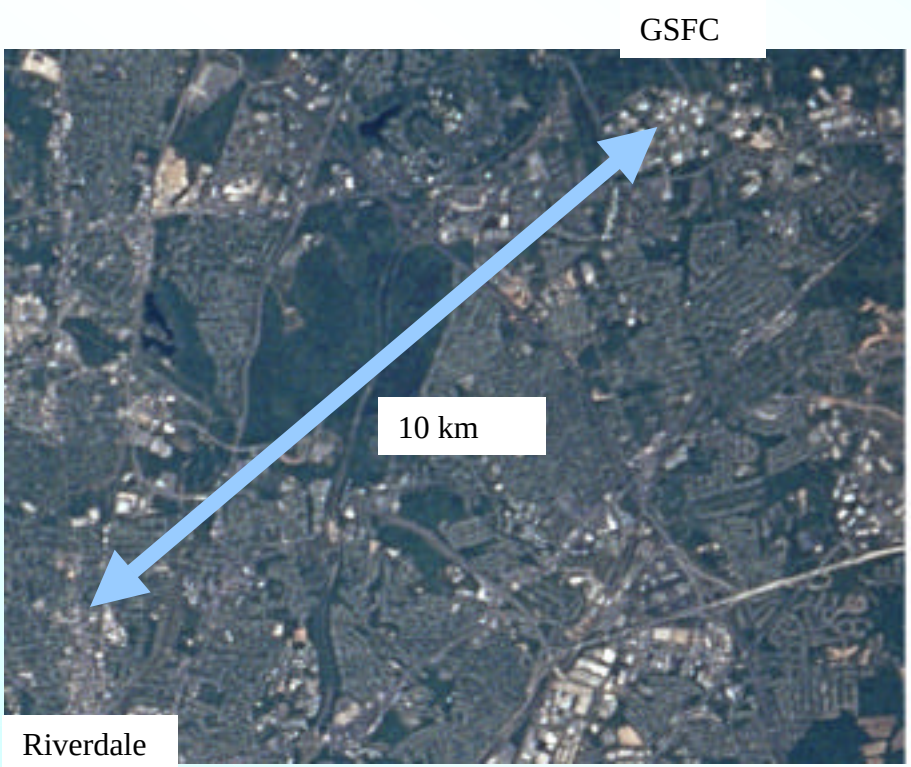


Program Relevance

- The application of Internet technologies to Space systems will significantly reduce the development costs for future missions while greatly increasing the flexibility of those missions. A hybrid solution including both UDP and TCP/IP are envisioned.
- New distributed system and mission models are enabled
- State of the Art Application programming techniques and expertise are directly transferred to the Flight environment
- Spacecraft using IP protocols enables Seamless routing of data, E-Mail, SMTP servers,Virtual private networking, FTP transfers, Remote File systems and Java interfaces and other custom protocols as appropriate
- Large blocks of COTS software will be directly transferable to flight platforms once NASA adopts this new way of designing space missions and hardware

The SOMO Space Internet Campaign at GSFC is taking the lead to coordinate space Internet activities at GSFC and beyond. Industry is looking for the government to take the lead. The GSFC community is moving as quickly as possible to prototype and demonstrate these technologies and methodologies and infuse them into flight missions.

The Open internet as it applies to Space Missions



Short Network Hop From Riverdale to GSFC is 40-50 msec.

This delay is driven by network topology issues and routing delays.

Even with this 40-50msec delay connectivity with GSFC is essentially seamless. All the basic protocols function: TCP/IP, FTP, HTTP,JAVA, etc.

- **The peer network model has proven to be the most flexible and cost effective when it applies**
- **The peer network model does not break at a particular delay or delay bandwidth product because the degree of interaction between the client and server are determined by the application program.**
  - For Example SQL data base access usually will not function over a GEO sat hop.
  - FTP on the other hand can easily be tuned to work over a GEO hop
- **Basic Assumptions made for campaign planning**
  - The TCP/IP network model is applicable to all Low earth orbit missions. Max one way delay about 0.066 seconds.
  - The peer networking model can be used through GEO hops with care. TCP may be tunable for particular applications.
    - This is an active area of research and experimentation
  - The peer network model breaks down beyond GEO. IP compatible file delivery can be used, and spacecraft in close proximity can communicate as peers. IP will still provide basic compatibility to allow all assets with compatible RF gear to communicate
  - Basic bulk data delivery function will be performed using UDP protocol with some form of negative acknowledgement and automatic forwarding.
  - Peer network channel will be used for command and control, instrument configuration, debugging, real time monitoring, etc.
  - Back door command capability will still exist.

The Open internet as it applies to Space Missions

Leo Spacecraft are actually very close to the earth. The main impediment to considering them to be part of a continuous peer network is the intermitent contact with ground stations.

If Leo space assets could network themselves together continuous low rate command and telemetry could be provided using adhoc networking teqniques.

This would require space-space communications and true standardization of the space communication infrastructure

Peer network model would also drive TDRS replacement strategy in 2015 time frame

- **Technology developments are required to enable this vision**
  - Flexible communications equipment and modems based on advanced digital receiver technology-LPT under development today
  - Space based mobile router technology can enable ad hoc networking concepts. All science spacecraft can provide and share communications assets.
  - On board Lan technology to allow instruments to connect to standard on board routers, processors and recorders
  - On board data storage and processing units with standard Network interfaces
  - Higher uplink rates from GN links would be helpful but require no technology development

On Board Network Roadmap

- **Several Lan card developments are currently under way and should provide 100 Mega bits per second DMA capable connectivity within 2 years.**
  - JPL X2000 IEEE-1394 interface board - Flight ASICS currently in work
    - Will likely be the first flight qualified card but will be used by high end customers
  - GSFC and ESA have IEEE-1355/Spacewire activities underway
    - Flight qualified NIC cards will likely be possible in about 1 year
    - Current activity funded through breadboard
  - GSFC developing a breadboard Ethernet Lan card
  - In principle IP could be transported across standard serial or even MIL-STD-1553 interfaces
    - Current generation PPPoE systems are deployed and working.
    - PPP over serial linkds has existed for many years and could be used now if desired
- **On board Routers and gateways**
  - Single point routers and gateways are currently under development
    - Initial SCPS Gateway developed for DSRV mission
    - Glenn research center has been working with CISCO and industry on a space router which would support IP SEC and Mobile IP - Not sure about current status
    - GSFC/ITT are developing router for LPT digital radio Shuttle flight.
- **On board Communications Technology**
  - Digital reconfigurable radios are required to allow missions developed and launched decades apart to interoperate. IP protocols would be the backbone allowing this interaction to occur.
  - Studies have been initiated to look at extending the LPT concept to space to space communications
  - Higher uplink rates are available whenever missions need them. No technology needs to be developed to reduce the asymmetry of the link.

Ground IP Roadmap

- **The ground already uses IP hardware. CCSDS packets are wrapped and delivered using IP.**
  - Ground system changes need further study. Many capabilities are enabled by advanced communication and the seem less connectivity of assets.
    - Mission autonomy is enabled by allowing a S/C to schedule and execute data downloads and uploads
    - The spacecraft can interact with the ground segment to optimize its data delivery and reduce overall data delivery costs
    - The spacecraft can interact with the ground data servers to enable 100% data delivery with minimum impact to the downlink channel rate.
- **Using IP will simplify the hardware needed at the ground station. The End point concept is to buy receivers with decoders included and build a simple interface between the receiver and a commercial router.**